ASC-TR-96-5009

JOINT VISUAL SYSTEM OPERATIONAL EVALUATION (JOINT VIS-EVAL) SITE 2
MCDONNELL-DOUGLAS VISUAL INTEGRATED DISPLAY SYSTEM (VIDS) EVALUATION

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13. ABSTRACT (Maximum 200 words)

This evaluation was a Joint Visual System Operational Evaluation (VIS-EVAL) to evaluate visual display devices. It was a multi-year effort including Air Force, Navy, and Marine pilots. This evaluation was the second of two visual evaluations. The first evaluation was conducted on the Advanced Fiber-Optic Helmet Mounted Display (AFOHMD) developed by CAE Electronics, LTD and is reported in a separate report. This evaluation was conducted at the Site Number 2. Its purpose was to identify the capabilities and limitations of the Visual Integrated Display System (VIDS) developed by McDonnell Douglas Aerospace Corporation. Specifically, the purpose was to (1) determine trainability of tactical mission tasks with available visual display technology; (2) demonstrate current visual simulation technology to users; (3) obtain feedback from those users to help define future visual requirements; (provide information and data to support future simulation acquisition decisions), and (4) provide feedback to manufacturers for product improvement. This system was a multi-faceted, rear-projected, real-image screen display. A team of highly experienced F-15E, F-16C and FA-18C/D instructor pilots evaluated the VIDS using fighter tasks in a mission context. USAF Formal Training Unit (FTU) and USN/USMC Fleet Replacement Squadron (FRS) training levels were used as the benchmark for the evaluation. The VIDS that was evaluated provided a large Field-of-View (FOV) display of both background imagery and other aircraft imagery. The background imagery requires improvement for low level navigation, ground target identification and other low altitude tasks. Results and discussion indicate that the VIDS provides training capability for selected fighter tasks.

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ACRONYMS

A/A	Air-to-Air
ACC	Air Combat Command
ACM	Air Combat Maneuvering
AFB	Air Force Base
AFMC	Air Force Materiel Command
AGL	Above Ground Level
AHC	Aircraft Handling Characteristics
AOI	Area-of-Interest
BFM	Basic Fighter Maneuvering
COTS	Commercial Off The Shelf
CRT	Cathode Ray Tube
DART	Display For Advanced Research and Training
DB	Dive Bomb
DFAD	Digital Feature Analysis Data
DIS	Distributed Interactive Simulation
DMA	Defense Mapping Agency
DTED	Digital Terrain Elevation Data
ESIG	Evans and Sutherland Image Generator
FFOR	Full Field Of Regard
FFOV	Full Field of View
FLOLS	Fresnel Lens Optical Landing System (meatball)
FOHMD	Fiber-Optic Helmet Mounted Display
FOR	Field of Regard
FOV	Field of View
FRS	Fleet Replacement Squadron
FTU	Formal Training Unit
HAS	High Angle Strafe
HD	High Angle Dive Bomb
HRI	High Resolution Inset
HUD	Head-Up Display
ID	Identification
IFR	Instrument Flight Rules
IG	Image Generator
IP	Initial Point
IP	Instructor Pilot
JAST	Joint Advanced Strike Technology
LAB	Low Angle Bomb
LALD	Low Angle Low Drag
LAS	Low Angle Strafe
LAT	Low Altitude Training
LATS	Low Altitude Training System
LOD	Level of Detail
NAWCAD	Naval Air Warfare Center Aircraft Division

NM	Nautical Miles
NR	Not Rated
MDTS	McDonnell Douglas Training Systems
RTB	Return to Base
RWR	Radar Warning Receiver
SA	Situation Awareness
SAM	Surface-to-Air Missile
Texels	Texture Elements
TSRA	Training System Requirements Analysis
USAFE	United States Air Force in Europe
VFR	Visual Flight Rules
VIDS	Visual Integrated Display System
VLD	Visual Lay Down
WTT	Weapons and Tactics Trainer

PREFACE

This report summarizes the findings of the joint visual system evaluation of the McDonnell Douglas Aerospace Visual Integrated Display System (VIDS) located at McDonnell facilities in St. Louis, MO. This report is not intended to qualify the system from either an operational or engineering perspective but rather to identify tasks that could and could not be trained with this visual display. The effort was funded and managed by the Training Systems Product Group, Aeronautical Systems Center, Wright-Patterson AFB, OH with Joint Advanced Strike Technology (JAST) funding and support. Evaluators were provided through arrangement with the Air Combat Command (ACC), Langley Air Force Base, VA and the Naval Air Systems Command, Arlington, VA. Lt. Col. Harry Daye was the Evaluation Team Chief; and Mr. Jim Brown of the Training Systems Product Group was the Training Analyst and Lead Engineer. Support was received from Lt. David Street, Ph.D., of the Naval Air Systems Command, PMA 205 Training Systems Program Manager. There were eight evaluation pilots including four USAF, two USN, and two USMC. They averaged 2275 flying hours and almost 800 hours as Instructor Pilots (IPs). The Evaluation Team consisted of:

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Maj John Ayres, USAF
Lt Luther Hook, USN
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Lt F.T. Wallace, USN
Capt Mitch Reeves, USAF.

The Training Systems Product Group extends special thanks to the Air Combat Command and the Naval Air Systems Command for supporting the effort and to the dedicated evaluators who gave their time and effort to the project.

The authors wish to express their appreciation to McDonnell Douglas Training Systems at St. Louis, MO who provided their facilities and support personnel for the evaluation. Also to Evans and Sutherland of Salt Lake City, UT for their support in providing the Image Generator (IG) and Database. Special thanks are due to:

Mr. David Coblitz, McDonnell Douglas Training Systems
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EXECUTIVE SUMMARY

The Training System Program Office (SPO) initiated a Training Systems Requirements Analysis (TSRA) in response to a March, 1989 request from USAFE to investigate low altitude training needs for the 1990s. Recommendations made in 1991, based on that analysis, indicated that modern visual systems have the potential to significantly enhance available tactical aircraft training and may assist in slowing down the loss of critical low altitude flying skills that are not frequently practiced.

The Visual Evaluation (Vis-Eval) Program was created in 1992 by ASC/YW to evaluate the adequacy of image display technology to support low altitude training. Its purpose was to (1) determine trainability of tactical mission tasks with available visual display technology; (2) demonstrate current visual simulation technology to users; (3) obtain feedback from those users to help define future visual requirements; (4) provide information and data to support future simulation acquisition decisions, and (5) provide feedback to manufacturers for product improvement.

In 1993, ASC/YW, with the support of ACC, conducted the first Vis-Eval. In this report, we refer to the first Vis-Eval as Vis-Eval I. Vis-Eval I included evaluation of three different types of wide field-of-view (FOV) visual display systems which had the potential to meet tactical mission training needs. The results are documented in report ASC-TR-5030 dated July 1994.

Joint Vis-Eval is a follow-on effort to evaluate additional visual display devices. It was a collaborative effort between ASC/YW, NAVAIR (PMA-205), and the JAST Program Office. It was therefore modified to be a multi-service effort and included Air Force, Navy and Marine Corps pilots. In addition, the evaluation process has been restructured to incorporate lessons learned during Vis-Eval I.

The objective of the initial Joint Vis-Eval at Site 1 was to identify the capabilities and limitations of the latest generation of Advanced Fiber-Optic Helmet Mounted Display (AFOHMD) developed by CAE Electronics, Ltd. This evaluation was conducted at the NAWCAD, Patuxent River, MD. The results of this evaluation will be reported in a Joint Visual System Operational Evaluation Final Report as an ASC Technical Report.

The objective of the second (Site 2) Joint Vis-Eval was to identify the capabilities and limitations of the VIDS developed by McDonnell Douglas. This system is a multi-faceted, rear-projected, real image screen display. The system for this evaluation had four screens for a total FOV of 216 degrees horizontal by 135 degrees vertical. With the addition of three screens, a complete 360 degree out-the-canopy FOV can be obtained. This second evaluation was conducted at McDonnell Douglas in St. Louis, MO.

A team of highly experienced F-15E, F-16C and FA-18C/D instructor pilots evaluated the VIDS, using fighter tasks in a mission context. USAF Formal Training Unit (FTU) and USN/USMC Fleet Replacement Squadron (FRS) training levels were used as the benchmark for the evaluation. Each evaluator flew three missions, a familiarization and two evaluation missions. At the end of each evaluation mission, the pilot completed a questionnaire and debriefed the analysis team to document the task training capability of the display system.

The results of the VIDS Joint Vis-Eval are presented in this report in detail. Major conclusions are summarized below:

The VIDS display that was evaluated provides a large FOV display of both background imagery and other aircraft imagery. The background imagery resolution requires improvement for low level navigation, ground target identification and other low altitude tasks. The other aircraft imagery resolution was acceptable.

Four of the twelve single aircraft tasks evaluated by the team were rated trainable (Figure 3-2).

Eight of the twenty multiple aircraft tasks evaluated by the team were rated trainable (Figure 3-3).

SECTION 1 - INTRODUCTION

1.1 BACKGROUND

1.1.1 Ground-based simulator training for tactical fighter aircrews is limited by lack of adequate visual display systems. Efforts to develop visual systems with the capability to provide useful tactics training have met with limited success. A major requirement of tactical visual systems is that the display must have a large, instantaneous FOV both horizontally and vertically and a field-of-regard (FOR) limited only by the aircraft structure. This requirement has been difficult for industry to meet while still providing resolution and brightness that is adequate to realistically train tactical flying tasks. Other visual system constraints have been evident in the area of database size and detail. Fighter aircraft rapidly traverse long ranges in very short time spans. These large distances and high speeds place major burdens on data base development and image generation. Fighters also operate at altitudes ranging from the surface to 40,000 feet. Fighter pilots are required to recognize airborne objects, such as another F-16 or F-18, at realistic tactical ranges, assess the range, aspect and closure of another aircraft, and fly tactical formation. They must also accurately identify ground objects such as vehicles, roads and bridges. This wide range of requirements has made it difficult for industry to develop display systems which meet the full range of fighter training requirements.

1.1.2 In the past, the Air Force conducted operational evaluations to determine if advances in visual system technology could provide the capability to train tactical flying tasks. Among those efforts were Project 2235, Air-to-Ground Visual Simulation Demonstration (1976), Simulator Systems Comparative Evaluations (1977, 1979), and the F-15 Limited Field of View Visual System Training Effectiveness Evaluation (1984). The general findings of those efforts indicated that existing visual systems could train some, but not all, critical tactical flying tasks.

1.1.3 In March 1989, the United States Air Force In Europe (USAFE) requested assistance from the Air Force Systems Command (AFSC) in determining ways to meet its low altitude training needs for the 1990s. USAFE aircrews were limited to training at altitudes of no less than 250 feet and at airspeeds of no more than 475-550 knots. A training systems requirements analysis (TSRA) was conducted for the F-16C and F-15E weapon systems. The analysis recommendations indicated that modern visual systems had the potential to significantly enhance available tactical aircraft training and could assist in slowing down the loss of critical low altitude flying skills not frequently practiced due to range or safety constraints. To verify adequacy of image display technology to support low altitude training, an operational evaluation using aircrews was suggested.

1.1.3.1 As a result, ASC/YW, with the support of ACC, conducted what has been referred to and reported as Visual System Operational Evaluation, or Vis-Eval. We refer to the first Vis-Eval as Vis-Eval I in this report. Vis-Eval I included: Site #1, a Two Channel Area of Interest Dome Display developed by Evans and Sutherland and evaluated at the manufacturer's plant in Salt Lake City, UT; Site #2, the Display for Advanced Research and Training (DART), evaluated on site at Armstrong Labs, Williams Gateway Airport, AZ; and Site #3, the Fiber-Optic Helmet Mounted Display (FOHMD), developed by CAE Electronics, Ltd., Montreal, Canada, and

evaluated at CAE Stolberg, Germany. The results of those evaluations are reported in ASC-TR-94-5030, July 1994. The objective of the initial Joint Vis-Eval at Site 1 was to identify the capabilities and limitations of the latest generation of FOHMD developed by CAE Electronics, Ltd. That evaluation was conducted at the NAWCAD, Patuxent River, MD. The results of this evaluation will be reported in Joint Visual System Operational Evaluation Final Report as an ASC Technical Report.

1.1.3.2 The objective of the initial Joint Vis-Eval operational evaluation at Site 2 was to identify the capabilities and limitations of the McDonnell Douglas Visual Integrated Display System (VIDS). The evaluation was conducted at McDonnell Douglas Training Systems in St. Louis, MO using a production F-16 Weapons & Tactics Trainer (WTT) with a 29 inch monitor visual display networked via Distributed Interactive Simulation (DIS) protocols to an F-15C WTT-like demonstration crewstation with the VIDS, a threat system including surface-to-air threats, an auxiliary operator station (able to assume control and manually fly one or more threats), and a combat battle monitor providing an overview of the activity.

1.1.4 Display technology has improved since Vis-Eval I and these improvements were evaluated for possible application to new visual system requirements. Joint Vis-Eval was a follow-on effort to evaluate these improved devices. Joint Vis-Eval differed from Vis-Eval I in several ways. It is now a multi-service effort including Air Force, Navy and Marine pilots and jointly funded by the Joint Advanced Strike Technology (JAST) Program and ASC/YW. The evaluation process has also been restructured to incorporate lessons learned during Vis-Eval I.

1.2 AREAS TO BE INVESTIGATED

A visual system, in its most elemental form, is comprised of the combination of a data base, an image generator (IG) and a visual display system. This evaluation, similar to Vis-Eval I and Joint Vis-Eval Site 1, focused on the display system.

1.3 PURPOSE

The purpose of this effort was to continue to operationally evaluate available visual image display technology for potential application to operational training of tactical fighter aircrews.

1.4 SCOPE AND LIMITING FACTORS

The evaluation was conducted at McDonnell Douglas Training Systems, St. Louis, MO during 11-15 September 1995. This evaluation consisted of two activities. The first activity was the operational evaluation conducted by multi-service fighter pilots. The second was the engineering review of the system. This report is not intended to qualify the system from either an operational or engineering perspective.

1.4.1 Operational Evaluation

1.4.1.1 The operational evaluation used an evaluation team comprised of eight instructor pilots (four USAF, two USN, and two USMC) with current FA-18, F-16C or F-15E experience.

1.4.1.2 The focus of the operational evaluation was to evaluate the training capability of the VIDS to support USAF Formal Training Units (FTU) and USN/USMC Fleet Replacement Squadrons (FRS). It was not structured as an experimental comparison. Instead, aircrews were asked to rate the training capability of the visual display system under evaluation. Due to large differences in weapon system components and performance capability, it is not possible to compare one visual system to another. Rather, the intent of this evaluation was to rate the capability of the VIDS to support training of tactical mission tasks.

1.4.1.3 Even though the visual display was the focus of this evaluation, it was recognized that cockpit differences from the aircraft, image generation capability and database characteristics impacted training ratings. Only subjective aircrew data was gathered during the operational evaluation. Objective data, such as bombing scores, hits, etc., were not available.

1.4.2 Engineering Review

1.4.2.1 Engineering data describing the attributes of both the VIDS display and image generator at the time of the evaluation were solicited and received from McDonnell Douglas and Evans and Sutherland, respectively. This data is included in Annex H. Operational reliability and maintainability issues were not evaluated although general availability of systems was noted.

1.5 SPECIFIC OBJECTIVES

1.5.1 Objective 1. Operationally evaluate the capability of the VIDS technology to support training of selected tactical mission tasks (Annex B).

1.5.2 Objective 2. Baseline and document the engineering attributes for the simulator configuration at the time of the evaluation. Emphasis is placed on the visual display, image generator, and database.

SECTION 2 - METHOD OF ACCOMPLISHMENT

2.1 METHOD OF TEST

2.1.1 Operational Evaluators. Eight pilots were selected for this evaluation including four Air Force, two Navy, and two Marine pilots. All pilots had extensive fighter and fighter instructor pilot experience in the F-15E, F-16C, or FA-18 with one of the pilots having combat experience. Both Marine pilots were TOPGUN graduates and one pilot was an instructor at the school at the time of the evaluation. The average flying time for the pilots was 2275 hours; average instructor time was 788 hours.

2.1.2 Training for Evaluators. Training for the team was provided in visual system technology and the evaluation process at the Flight Dynamics Laboratory Simulation Facility at Wright Patterson AFB, OH. Classroom instruction and demonstration training on visual system technology were given to evaluation pilots for recognition of visual features related to visual displays, visual image generation, and databases. This training enabled the evaluators to better converse during the debrief on technical issues, to assess the inter-relationship of visual system components, and to focus on visual displays for training capability ratings.

2.1.3 Operational Procedure. The evaluation was conducted over a one week period. A familiarization mission and two generic tactical evaluation missions were developed to permit the pilots to evaluate each of 12 single aircraft and 20 multiple aircraft tasks. Most tasks were further divided into a series of subtasks. The tasks, subtasks, missions, and mission events were developed by the Joint Vis-Eval Pilot Team during an initial meeting six weeks prior to the start of the first evaluation at Site 1 and were approved by the Evaluation Team Chief. A complete list of tasks and subtasks is located in Annex B. Not all tasks were flown on each mission, but the missions were structured to cover each task and subtask at least once during the evaluation. The Familiarization Mission was structured to orient pilots to the F-15C, F-16 auxiliary operator station, and the visual system as well as to acclimate the pilots to the system. Each evaluation mission consisted of a set of events (air-to-surface, air-to-air, formation, threat reaction, etc.) to evaluate the tasks in a mission context. Mission events increased in complexity from single aircraft events in the beginning of Mission 1 to complex multiple aircraft events later in Mission 1 and in Mission 2. The multiple aircraft events were flown as a two aircraft element against various air and ground threats.

2.1.3.1 Before the evaluation, the Team Chief developed four low level routes to be flown. The day before the arrival of the first team, the Team Chief and supporting personnel evaluated the systems at the McDonnell Douglas facility to finalize the conduct of the evaluation.

2.1.3.2 Pilots were organized into four teams, each with one USAF and one USN or USMC pilot. The multi-service teams were devised to better integrate the results of the evaluation. Upon arrival, each pilot team was briefed on facilities, procedures, and schedule of events.

2.1.3.3 Team members briefed and flew each mission as a two aircraft flight, one pilot in the

F-15 cockpit with the VIDS and one in the F-16 cockpit. They then reversed roles to repeat the mission. After each mission, pilots individually rated each task and subtask using the rating scale shown in Annex E and filled out the questionnaire shown in Annex F. Additionally, an individual debriefing was conducted to discuss the ratings and comments. All debriefings were recorded on tape for additional reference. Discussions were held with the pilots both during the evaluation and at the time of the debriefs to identify the strengths and limitations of the system.

2.1.4 Engineering Review. Engineering data were requested from and discussions held with McDonnell Douglas representatives and the supporting visual system contractor personnel. Observations of system performance were made and noted for further discussion. During the evaluation, available data were analyzed and any requirements for additional data identified. A detailed description is presented in Annex H.

2.2 METHOD OF EVALUATION

2.2.1 Operational Evaluation. Two criteria were used to evaluate the VIDS. The measures of effectiveness were the evaluation pilot subjective ratings in accordance with Annex E criteria and the evaluation teams' assessment of the capability of the VIDS to train pilots in an operational training environment. The criteria were that at least eighty percent of the ratings for the task must receive a score of three or higher (first criterion) or the task must receive an overall acceptable assessment by the evaluation team (second criterion).

2.2.2 Engineering Description. The intent of the engineering review was to document visual system characteristics as they were observed at the time of the operational evaluation. Detailed descriptions, as provided by McDonnell Douglas and Evans and Sutherland, are presented in Annex H. There was no attempt at the time of the evaluation to verify this data by either measurement or analysis.

2.3 SYSTEMS ENGINEERING DESCRIPTION

2.3.1 VIDS and ESIG 3000 Image Generator. A detailed description of the visual system characteristics is presented in Annex H.

2.3.1.1 Evaluation Cockpit and Aircraft Simulation. The evaluation cockpit was similar to an F-15C Weapons Tactics Trainer (WTT) developed by McDonnell Douglas Training Systems (MDTS). The cockpit replicated the physical and functional controls and displays of the F-15C Weapon System. Flight performance of the simulated aircraft was representative of the F-15C Weapon System. A stick spring cartridge and force sensor system was integrated for flight control.

2.3.1.2 HUD Display. The evaluation cockpit did not include a physical HUD. A HUD image was projected on the front display screen overlaid on the projected background image. The HUD image provided all of the information normally displayed by a physical HUD. A mask representing the HUD supports was included. A physical representation of the canopy bow was attached to the cockpit.

2.3.1.3 Image Display. The display system was a four channel mosaic rear-projection flat screen display that provided a horizontal FOV of 216 degrees and a vertical FOV of 135 degrees. Figure 3-1 shows the cockpit and display. A low cost, high resolution color CRT projector provides the background imagery on each screen. Multiple, high resolution target images were also projected on each screen.

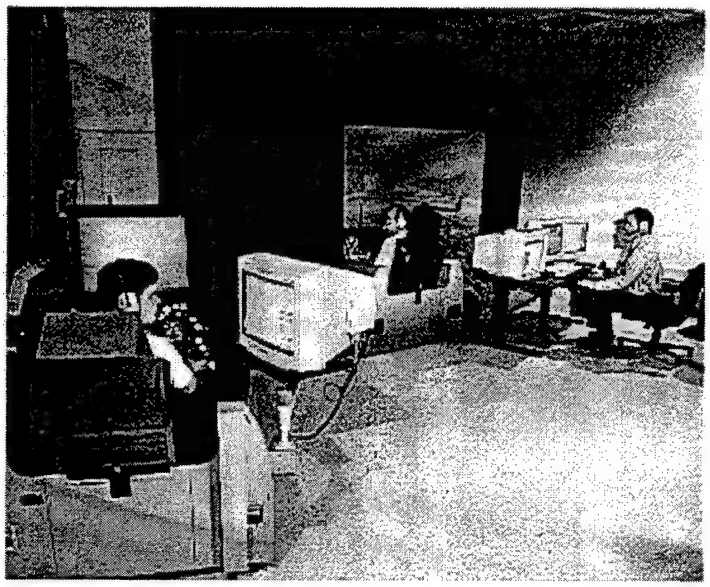


Figure 3-1 VIDS Cockpit And Display

2.3.1.4 Image Generation. The background imagery was generated by an Evans and Sutherland ESIG-HD 3000 AT. A separate low cost image generator generated the target imagery which was projected by the target projector for the target aircraft and other aircraft on each screen. The targets were fully textured and anti-aliased. The ESIG-HD 3000 AT provided the capability of 3300 potentially visible polygons per screen (13,200 polygons/system) including polygons, lights and models for system operation at 60 Hz. It included full color, intensity and contour modulated, and photo texture to maximize image detail while simultaneously preventing system overload. Blending was provided between levels of detail (LOD) in order to prevent abrupt changes in the image when LOD changed. For portions of the evaluation, a fifth background channel was generated and presented in the HUD FOV. This provided higher resolution to support carrier landing (FLOLS or "meatball") and low level flight and ground target detection.

2.3.1.5 Database. The database used in the evaluation was Central California, including Hunter Liggett and NAS Lemoore. Source data was DFAD and DTED Level 1. The database, an E&S RapidDatabase ™, was produced in two weeks using DMA source materials and enhanced along the mission routes using inputs from USAF personnel. DMA source data problems were generally not corrected unless they were in view of the mission route.

2.3.1.6 Support Cockpit and Equipment. A simulated second aircraft was provided which was representative of the F-16 Block 50. Its out-of-the-window displays were comprised of a 29 inch visual display monitor driven by an ESIG 2000 image generator running the identical database as on the F-15C and a tactical overview display. The two cockpits were networked and flew as a two aircraft element against threats generated by either the F-15 WTT internal threat system or the Big Tac threat system. The Big Tac threat system is derived from the threat system used to train F-14 pilots, ported to run on a low cost microprocessor workstation. It provided the aircraft carrier and surface-to-air threat dynamics during the evaluations. A combat battle monitor on a large screen provided an overview of all entities in the battle including radar coverage of the aircraft.

SECTION 3 - RESULTS AND DISCUSSION

3.1 MISSION AND ENGINEERING PERFORMANCE

3.1.1 Training Mission Performance

The first objective of this evaluation was to determine the capability of the VIDS to support training of the evaluation tasks described in Annex B. The operational evaluation was conducted as discussed in para 2.2.1. The evaluation criteria are presented in Annex E. Results and discussion follow:

3.1.1.1 Tasks Evaluated. All of the 12 single aircraft and 20 multiple aircraft tasks originally identified in Annex B were evaluated during the missions flown.

3.1.1.2 Results and Discussion. The VIDS was evaluated as being capable of supporting FTU/FRS training for 4 of 12 single aircraft and 8 of 20 multiple aircraft tasks. The composite ratings for all single and multiple aircraft tasks are shown in Figures 3-2 and 3-3. Significant pilot comments for each task, and subtask where appropriate, are summarized below. A lower percentage of single aircraft tasks met the acceptable training criteria than multiple aircraft tasks. This is because single aircraft pilots rely primarily on the lower resolution background imagery to accomplish their tasks and multiple aircraft pilots primarily use the higher resolution other aircraft imagery as their primary reference with the lower resolution background imagery a secondary reference. The addition of the HUD High Resolution Inset (HRI) during the evaluation resulted in improved acceptability ratings since the HRI provided higher resolution background imagery. These improvements occurred as long as the required imagery normally transition into the forward FOV during performance of the task.

3.1.1.2.1 Annex G lists the ratings for each task and subtask by pilot team as well as the composite rating by the full evaluation team.

3.1.1.2.2 Single Aircraft Tasks. Discussion of each task follows.

3.1.1.2.2.1 Low Level. Did not meet acceptable training criterion.

Negative comments include:

Depth perception difficult to judge, sensation of being higher than actual altitude.
Not enough vertical development for speed and height cues.
Hard to see mountain passes or peaks; hard to determine if they are near or far from your position.
Inadequate texturing.

3.1.1.2.2.1.1 Navigation. Did not meet acceptable training criteria.

Negative comments include:

Database provides limited terrain and cultural navigation capability. Must rely on navigation system to get to target.

Features (roads, lakes, rivers) not always correctly correlated with map.

Need more cultural features ranging from big to small to find points/targets.

Little vertical development.

Objects appear out of focus until close range instead of changing size with decreasing distance.

Visual resolution not sharp enough to ID navigation points/targets until very late.

Insufficient contrast and resolution outside of HUD HRI area. Unable to ID targets until inside HUD HRI.

Ground targets pop into view instead of fading in.

3.1.1.2.2.1.2 Low Altitude Training. Did not meet acceptable training criteria.

Positive comments include:

Good simulation of ground rush.

Negative comments include:

Depth perception hard to judge; often ended up at very low altitudes without sufficient cues.

Insufficient texture, contrast and acuity outside HUD HRI to adequately do LAT.

3.1.1.2.2.1.3 Detect/ID Ground Threat. Did not meet acceptable training criterion.

Positive comments include:

Missiles visible as they flew by the aircraft.

Ground threats apparent at approximately 1-2 NM; OK for training.

SAMs generally good. A lighter color smoke trail would be more realistic.

Negative comments include:

Resolution not adequate to display threats/missile sites on the ground.

Can't see launch or ground threat until too late to react.

Unable to reliably detect ground threats outside HUD HRI.

3.1.1.2.2.2 Medium Altitude Maneuvering. Met acceptable training criteria.

Positive comments include:

Good line of sight movements across horizon and in vertical.

No problems at medium altitude. All cues are good.

3.1.1.2.2.3 Visual Weapons Delivery. Did not meet acceptable training criteria.

3.1.1.2.2.3.1 Low Altitude. Met acceptable training criteria.

Positive comments include:

Low altitude/low angle weapons delivery good.
Target ID adequate at low altitude.
Ground target ID no problem.

Negative comments include:

Possible to train, but difficult to ID targets due to display resolution.
Database too sparse to provide good cueing for target ID.
Unable to ID targets for delivery until inside HUD HRI.
VLD - need some vertical development in target area. Can't determine line of sight/closure until almost on top of target.

3.1.1.2.2.3.2 High Altitude. Did not meet acceptable training criteria.

Negative comments include:

Resolution marginal from medium to high altitude.
Hard to estimate range beyond 2 NM for roll in due to low resolution.
Sense of depth erratic resulting in incorrect dive angles.
Database too sparse to provide good cueing for target ID.
Possible to train but difficult to ID targets due to display resolution. Differences in screen resolution compound problem. Targets are routinely positioned by pilots at 10/2 o'clock where resolution is the poorest.
Unable to ID targets for delivery until inside HUD HRI.
Database target disappeared in pop up and didn't reappear until half way down final attack.

3.1.1.2.2.4 Approach/Landing. Met acceptable training criteria.

3.1.1.2.2.4.1 Day. Met acceptable training criteria.

Positive comments include:

Good training from 45 degree base position to centerline.
Overhead patterns good, except unable to see runway at 180 degree base position due to display FOV limitation.
Very good landing phase cues.
Day landings are good to excellent.
Closure/ground rush cues good.
Carrier landing very good, but would expect to see meatball at 1 NM not 2 NM.

Negative comments include:

Insufficient runway detail.
Difficult to judge lateral offset.

3.1.1.2.2.4.2 Night. Did not meet acceptable training criteria.

Negative comments include:

Night weather approach: runway lights visible at 10 NM while in weather.
Front display too dark, sides are about right, displays not matched.
With HRI, night landing impossible; center display too dark and runway lights too dim.
Night landings better with HRI removed, but lights should be brighter and crisper.
Runway environment insufficient to reliably train task; need more ground lights.
Displays blurry, not crisp and sharp.
Runway cues should be clearer at 5 NM.
Night scene at 10 NM appears as a single dot of light at the airfield with no other features.

3.1.1.2.2.5 General Situation Awareness. Did not meet acceptable training criteria.

Positive comments include:

Good forward of the 3/9 line, non-existent aft.

Negative comments include:

Mountains with lakes cut over the top and cities with square edges is not a realistic simulation.
Features (roads, lakes, rivers) not correlated with map.
Target ID later than would be expected.
Ground feature resolution inadequate.
Hard to judge distance/depth perception.
Low altitude peripheral cues missing resulting in less SA than required below 500 ft.

3.1.1.2.3 Multiple Aircraft Tasks. Eight of the twenty multiple aircraft tasks evaluated were rated as providing acceptable training.

3.1.1.2.3.1 Basic Tasks. Met acceptable training criteria.

3.1.1.2.3.1.1 Close Formation/Formation Rejoin. Did not meet acceptable training criteria.

Positive comments include:

Closure/aspect recognition apparent.

Negative comments include:

Transition from target to background projectors at about 500 ft caused a double image.
Displayed image disappeared randomly, moving from center to side display.
Side display at close range had ghost image (two different colored aircraft not superimposed).
Very jerky.
Close formation work very difficult.

3.1.1.2.3.1.2 Weapon System Checks. Met acceptable training criteria.

No comments.

3.1.1.2.3.1.3 Ranging Exercises. Did not meet acceptable training criteria due to display FOV limitations. Although the task met the 80% acceptable rating (Criterion 1), the team rated the task unacceptable (Criterion 2) since defensive ranging could not be performed.

Positive comments include:

Good 1000 - 9000 ft range clues for rear aspect target.
Provides good basic offensive training.
Aspect angle good for offensive exercises.

Negative comments include:

Difficult to judge range/aspect at greater than 9000 ft range.
At distances beyond 1.3 NM, range appeared to be greater than actual.
Unable to recognize high closure rates with target outside HUD HRI.
Defensive ranging unacceptable (not trainable) due to FOV limitations.

3.1.1.2.3.1.4 Air-to-Air Exercises. Met acceptable training criteria.

Positive comments include:

1000 - 9000 ft good range/aspect.
Aspect angle good for exercises.

Negative comments include:

Unable to recognize high closure rates with target outside HUD HRI.

3.1.1.2.3.2 Tactical Formation. Did not meet acceptable training criteria due to display FOV limitations. Although the task met the 80% acceptable rating (Criterion 1), the team rated the task unacceptable (Criterion 2) since the lack of FOV significantly limited the task.

Positive comments include:

Visual signals easily recognizable.
Range estimation good.
Could judge aspect angle at ranges inside 9000 ft.
Tactical Formation was good forward of 3/9 line.

Negative comments include:

Not trainable due to limited FOV aft of 3/9 line.
Difficulty with aspect determination outside 1.5 NM.
Aircraft detail outside 6000 ft inadequate to reliably determine lateral range.
Difficult to discern tactical turn direction due to less than 20/20 contrast/acuity.
Unable to recognize lateral drift rates outside 8000 ft.

3.1.1.2.3.2.1 Medium Altitude. Did not meet acceptable training criteria due to display FOV limitations. Although the task met the 80% acceptable rating (Criterion 1), the team rated the task unacceptable (Criterion 2) since the lack of FOV significantly limited the task.
For basic comments see Tactical Formation, para 3.1.1.2.3.2.

3.1.1.2.3.2.2 Low Altitude. Did not meet acceptable training criteria due to display FOV limitations. Although the task met the 80% acceptable rating (Criterion 1), the team rated the task unacceptable (Criterion 2) since the lack of FOV significantly limited the task.

For basic comments see Tactical Formation, para 3.1.1.2.3.2.

Other negative comments include:

With terrain between the two aircraft, it was possible to see other aircraft through mountain.

Unable to maintain line abreast formation at 500 ft or less due to lack of visual cues and low 3/9 acuity/contrast (low side display resolution).

Ground avoidance cues missing in low altitude arena. Only adequate cues are in HUD HRI.

3.1.1.2.3.3 Threat Reaction. Did not meet acceptable training criteria.

No comments.

3.1.1.2.3.3.1 Air-to-Air. Did not meet acceptable training criteria.

Positive comments include:

Could acquire threats at realistic ranges, tallies at 4 - 7 NM.

Negative comments include:

Unable to react to bandits behind 3/9 line due to limited FOV.
Bandit aircraft aspect and closure hard to determine at greater than 2 NM.
Could not detect any cues of A/A threat weapons employment.

3.1.1.2.3.3.2 Surface-to-Air. Did not meet acceptable training criteria.

Negative comments include:

No visual indication of SAM launch or launch site.
Some SAM launch sites placed below ground level in the database.
Very difficult to visually pick up threats.
A/G threats appeared late (3000 - 6000 ft); line of sight OK.
Could not detect S/A threats at expected ranges outside the HUD HRI.
FOV limitation a problem for threat reaction.

3.1.1.2.3.4 Visual Weapons Delivery. Met acceptable training criteria.

Positive comments include:

Echelon attacks are workable; lead visible through most of the maneuver.
Could keep sight of wingman during echelon attacks.
Good formation training on ingress and roll in for both low and high altitudes.

Negative comments include:

Unable to maintain SA between element members at ranges outside 2 NM.
Hard to estimate range and altitude; hard to get correct dive angle.
Formation attacks are a problem due to limited FOV.

3.1.1.2.3.4.1 Target ID (IP/Target/Reattack). Did not meet acceptable training criteria.

Positive comments include:

No problems with weapons deliveries with regard to target ID.

Negative comments include:

Target recognition inadequate; terrain features very limited.
Lack of visual cues results in late target IDs.
Contrast/acuity did not allow for target recognition at sufficient ranges.
Decreased side display resolution hampered pop up attacks where targets should be routinely identified at 10/2 o'clock during the pop up.
Resolution was main weakness.

3.1.1.2.3.4.2 Low Altitude. Met acceptable training criteria.

See comments under Visual Weapons Delivery, para 3.1.1.2.3.4.

3.1.1.2.3.4.3 High Altitude. Did not meet acceptable training criteria.

See comments under Visual Weapons Delivery, para 3.1.1.2.3.4.

Negative comments include:

At high altitude and higher dive angles, hard to establish correct dive angle.
Difficult to recognize target.

3.1.1.2.3.5 Air-to-Air Tasks. Met acceptable training criteria.

Positive comments include:

Visual ID at ranges less than 6000 ft are probably realistic.
Good looking threat aircraft.
Air-to-Air was a strength. Worked effectively in training 2v4 setup.
Very good training for working the different weapons.

Realistic tallies and VIDs; good intercepts.
Excellent air-to-air simulator.

Negative comments include:

Late visual detection; target pops into view approximately 3 - 7 NM, then easy to track as white spot while in FOV.
Visual ID was difficult outside 1 NM; impossible outside 1.5 NM.
Late acquisition/ID of bandits the norm due to poor contrast/acuity.
Late recognition of range/closure/aspect angle.
Noticeable resolution problems in side displays, mostly in left.
Major cues missing due to lack of rear visual displays.
Low altitude features didn't provide depth cues. Cues for ground avoidance missing.
Ground rush was not always apparent.

3.1.1.2.3.5.1 Intercepts. Met acceptable training criteria.

See general comments under Air-to-Air, para 3.1.1.2.3.5.

Positive comment:

Good intercept simulator.

3.1.1.2.3.5.2 Basic Fighter Maneuvering. Did not meet acceptable training criteria due to display FOV limitations. Although the task met the 80% acceptable rating (Criterion 1), the team rated the task unacceptable (Criterion 2) since the limited display FOV did not permit defensive or high aspect BFM. See general comments under Air-to-Air, para 3.1.1.2.3.5.

Positive comment:

Aspect, range, and line of sight OK forward of 3/9 line.

Negative comments include:

BFM is limited to offensive only.
Limited FOV limits training high aspect BFM; unable to determine target aircraft maneuvers.

3.1.1.2.3.5.3 Air Combat Maneuvering. Did not meet acceptable training criteria.

See comments under Air-to-Air, para 3.1.1.2.3.5.

Negative comments include:

ACM training inadequate; cannot effectively monitor wingman position due to limited FOV.
Outside of 2 NM, can't see air targets inside display, so re-entry difficult to judge.
Lack of display aft of 3/9 line made maneuvering relative to target aircraft nearly impossible.

Resolution limitations apparent at the longer ranges in ACM where range, aspect and closure cues were lacking.

3.1.1.2.3.6 General Situation Awareness. Met acceptable training criteria.

Positive comments include:

Good training in building SA while flying as an element.

Good as long as bandits/lead is forward of the 3/9 line; decreases rapidly to zero in rear quadrant.

Generally adequate for most tasks.

Negative comments include:

Poor side display resolution at ranges greater than 2 NM detracts from judging air-to-air entries.

Lack of sharpness of terrain features and database detail detracts from SA.

The display FOV limits overall SA.

SINGLE AIRCRAFT

% of Tasks Rated 3 or Higher	Composite
Low Level	64
Navigation	50
Low Altitude Training	71
Detect/ID Ground Threat	50
Medium Altitude Maneuvering	93
Visual Weapons Delivery	79
Low Altitude	86
High Altitude	64
Approach/Landing	80
Day	100
Night	33
General Situation Awareness	63

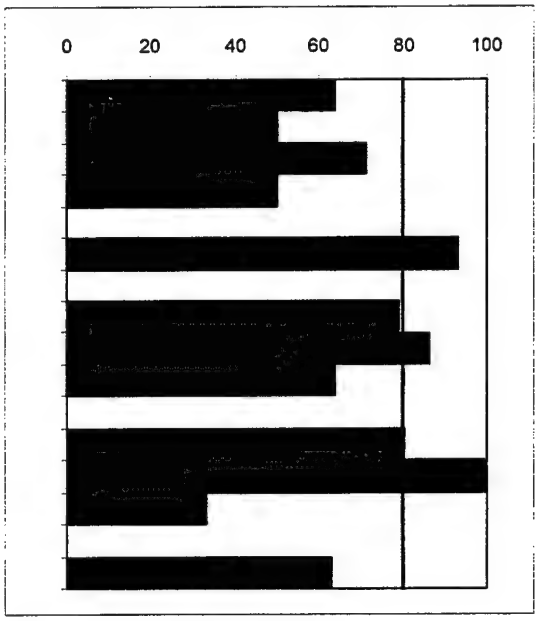
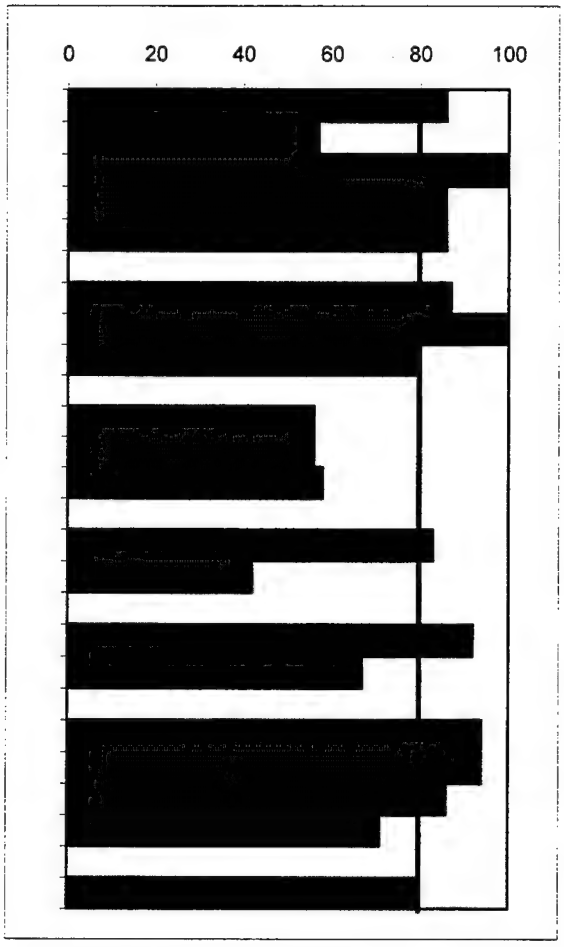


Figure 3-2 Single Aircraft Task Composite Ratings

MULTIPLE AIRCRAFT

% of Tasks Ratings 3 or Higher	Composite
Basic Tasks	86
Close Formation/Formation Rejoi	57
Weapon System Checks	100
Ranging Exercises	* 86
Air-to- Air Exercises	86
Tactical Formation	* 87
Medium Altitude (10-20K Feet)	* 100
Low Altitude (300-5K Feet AGL)	* 80
Threat Reaction	56
Air-to-Air	56
Surface-to-Air	58
Visual Weapons Delivery	83
Target ID (IP/Target/Reattack)	42
Types	
Low Altitude	92
High Altitude	67
Air-to-Air Tasks	94
Intercepts	94
Basic Fighter Maneuvering	* 86
Air Combat Maneuvering	71
General Situation Awareness	80



*** Tasks Not Meeting Second Criterion (Downgraded to Not Acceptable)**

Figure 3-3 Multiple Aircraft Task Composite Ratings

3.1.2. Engineering Performance

The second objective of the evaluation was to baseline and document the engineering attributes of the VIDS at the time of the operational evaluation.

3.1.2.1 Visual Display. The visual display is a multi-screen, rear-projection display. The rear projection screens are located approximately 28 inches from the pilot's eye. The system as evaluated included four display screens providing a total FOV of approximately 216 degrees horizontal by 135 degrees vertical. The system has the potential to provide a full 360 degree horizontal by 135 degree vertical FOV by adding three display screens to the rear of the existing display system. Background projectors provide full color background imagery, near range other aircraft, and near range target aircraft. Long range other aircraft and target aircraft are projected on each screen by a target projector. Contrast of the background image is very high. Target projector image contrast against the background image varies depending on the background scene brightness. Provisions are included to align targets and backgrounds between screens and to each other. Detailed characteristics of the display system are provided in Annex H of this report.

3.1.2.2 HUD Display. The visual system and cockpit did not include actual HUD hardware. HUD symbology was projected on the front screen of the display overlaying the background imagery. The HUD projector had a field-of-view of 22 by 15 degrees which provides much higher resolution of the background image in this area. The HUD electronics are similar to the background projector electronics.

3.2 GENERAL TECHNICAL OBSERVATIONS

3.2.1 Technical Observations

The VIDS consists of multi-facet screens that are mosaicked together to provide a continuous image to the pilot. For each facet or screen, there is a background projector and a target projector. The background projectors provide full color sky, terrain, near range target and near range other aircraft images. The target projectors provide high resolution targets and other aircraft imagery at programmable ranges beyond the capability of the background projectors. The VIDS display is a very "pilot friendly" display because it does not require the pilot to wear a special helmet with display optics or head or eye tracking devices. It is also not necessary for the pilot to perform any special display calibration process.

3.2.1.1 System Contrast. The VIDS has excellent system contrast characteristics.

3.2.1.2 Brightness. The high light brightness of the display is acceptable for meeting the pilot's needs. With either a four or seven screen display, there should be sufficient brightness to provide a realistic daylight condition within the cockpit.

3.2.1.3 Background Projector Resolution The background resolution of the VIDS varies with the different facets or screens of the display. The front screen has the best background resolution.

3.2.1.4 Target Projector Resolution. The resolution of the target projector is more than two and one half times the resolution of the background projection.

3.2.1.5 HUD Projector. The HUD projector is similar to the background projector except that it uses a single green CRT and a different lens to cover the HUD FOV. The projected HUD image is of much higher resolution than the background since the HUD subtends a FOV of only 22 degrees by 15 degrees.

3.2.1.6 Image Generation Requirements. The cost of an IG is to a large extent determined by the number of pixels that must be computed during one time frame. The four screen VIDS , as evaluated, requires a total of approximately 3- 4 mega pixels at a 30 Hz update rate. A FFOV (360 degree) VIDS of seven screens would require 6-7 mega pixels and a VIDS for a four aircraft complex with an FFOV would require approximately 24- 28 mega pixels at a 30 Hz update rate. To increase background resolution, the projectors could be operated at a higher line rate and higher horizontal resolution. This may be accomplished by increasing the line rate from 1024 to 1400 lines and increasing the pixel count per line from 1280 to 1840. However, to support the projectors operating at higher resolution, the IG performance must be increased from .75-1 mega pixel per frame per projector to at least 1.7-2.3 mega pixels. For an FFOV four cockpit complex, the IG requirement would be at least 42-65 mega pixels per frame at a 30 Hz update rate.

3.2.1.7 HUD Projector Background High Resolution Insert. During the evaluation, McDonnell Douglas set up the VIDS so that the background image in the area of the HUD was generated by a separate sub channel in the IG. Since the HUD projector covers only 22 by 15 degrees FOV, it has over twice the resolution of the background image. The higher resolution of the HUD projector and higher number of pixels output by the IG over the smaller HUD FOV provides much higher resolution. To accomplish this insert, the IG was operated at a 30 Hz update rate rather than 60 Hz.

3.2.2 System Complexity

3.2.2.1 Display Operation, Reliability and Maintenance. Although the VIDS does not include the complexity of devices such as magnetic head trackers and eye trackers which many FFOR visual displays include, it does include the complexity of multiple projectors which must be kept aligned and target images which must be moved from facet to facet across multiple display joints. A display system should require minimum attention on a day-to-day basis of operation. This includes alignment requirements, reliability of operation, and preventive and corrective maintenance.

3.2.2.1.1 Background Image Alignment Between Screens. Image alignment between the display screens is highly critical. Any misalignment of this imagery will be distracting to the pilot. Image alignment of a real image screen display is much more critical than a multi-facet optical

display where misalignment between facets will be compensated for by the viewer's eyes. Not only is the positional alignment of the image critical, but color and brightness match from screen to screen is also critical. The projectors need to be sufficiently stable so that alignment is required no more than once a day.

3.2.2.1.2 Background Projectors. The VIDS background projectors are commercial-off-the-shelf (COTS) high resolution color projectors. These projectors should be relatively reliable; however, alignment of these projectors for this application is much more critical than is required for most other applications. Image position alignment, brightness, and color alignment are highly critical for an edge registered, multi-screen display of this type. Since each background projector is a three CRT color projector, each background projector has essentially three complete sets of electronics, one for each of the primary colors. Without highly stable circuitry, it could be very difficult to keep the system properly aligned on a day-by-day basis.

3.2.2.1.3 Target Aircraft Image Alignment. There can be misalignment of target images as the target passes from one display screen to another. If the alignment between the target aircraft image being projected on one screen is different from the alignment of the target aircraft image being projected on an adjacent screen, the pilot might see two aircraft at one time, one on each screen.

3.2.2.1.4 Target Aircraft Image Alignment Between Target Projector and Background Projector. When the target aircraft approaches the ownship, the target aircraft image is switched from the target projector to the background projector. When this occurs, if the displayed position of the target aircraft varies between the two projectors, the position of the target aircraft will appear to jump to a new position. Also, it is possible for the target aircraft to be projected by the target and background projectors simultaneously and in different positions resulting two separate target aircraft images.

3.2.2.1.5 Four Cockpit Simulator Complex. It is well known that the Services are highly interested in the ability to simulate a four aircraft element operating together in a training scenario. It should be noted that all of the complexity comments stated previously in paragraphs 3.2.2.1 through 3.2.2.1.4 are exacerbated by at least a factor of four for a VIDS system supporting a four cockpit simulator complex.

3.2.3 Positive Pilot Findings

3.2.3.1 High Resolution Inset (HRI). The HUD HRI significantly improved image clarity within the FOV of the HUD for all objects displayed by the background projector in the forward display. The limited fixed FOV, however, limited the utility of the improved clarity.

3.2.3.2 Air-to-Air Targets. Simultaneous air-to-air targets were provided throughout the displays allowing multiple aircraft engagements. Targets could be controlled by software and/or the instructor console either independently or in groups.

3.2.3.3 Range/Aspect. Air target range and aspect angle could be accurately determined within 2 NM.

3.2.3.4 Weapons Employment. Pilots felt the VIDS provided excellent visual offensive switchology and weapons employment training.

3.2.4 Negative Pilot Findings

3.2.4.1 Display FOV. The lack of displays aft of the 3/9 line did not allow complete training in tactical formation, defensive BFM, advanced BFM/ACM/ACT and tactical ground weapons delivery maneuvering.

3.2.4.2 Side Display Resolution. The low resolution of the side displays limited the ability to locate and reference nav points/IPs/ground targets at expected ranges. The limitation was greater at medium and higher altitudes.

3.2.4.3 Medium to High Altitude Ground Resolution. Difficulty judging altitude and range to ground objects resulted in erratic dive angles. Difficult to identify specific ground objects or targets.

3.2.4.4 Air-to-Surface Targets. Specific ground targets were difficult to locate due to poor resolution outside the HUD HRI as well as the limited database. The difficulty became worse at medium and higher altitudes. Targets would appear to pop into view during weapons delivery final.

3.2.4.5 Air Targets at close range. During the transition from target projector to background projector at a range of 500 - 1000 ft, double images of the air target occurred and the target sometimes disappeared.

3.2.4.6 Night Scene. The displays were not well matched for the night scene. The HUD HRI was too dark and was best removed for night approaches. The night data base was much too sparse to provide references outside the airfield. Lights were not sharp and clear.

3.2.5 Non Visual Display Pilot Observations

3.2.5.1 Limited Database. The database was very sparse with many natural features not correlated with the map, limiting navigation and low altitude training. The database did not contain enough natural and cultural features to adequately locate or identify navigation points/IPs/ground targets limiting visual weapons delivery training. The database contained very few vertical cultural objects, natural features, and little texture thereby limiting low altitude cues.

3.2.6 Other Findings

3.2.6.1 Availability. There were seven visual system failures and one target to background projector transition problem during the evaluation period resulting in approximately 1 hour 30

minutes of lost time. The supporting F-16 WTT experienced two failures during the evaluation resulting in approximately 30 minutes lost time. On two other occasions totaling 1 hour, the system was not available to the evaluation team during scheduled evaluation time.

3.2.6.2 Cockpit Systems. Despite the initial unfamiliarity of some pilots with the F-15 and F-16 cockpit systems, pilots quickly adapted to the systems and the evaluation was not impacted.

3.2.6.3 Database. Throughout the visual evaluations, the importance of the scene content, texturing, and scene detail of the visual presentations continued to surface.

3.2.6.4 Physiological Effects. Each pilot was asked at the conclusion of each debrief whether he had experienced any form of illness such as nausea or disorientation. No unexpected incidents occurred. One pilot entered a spin and experienced a slight disorientation followed by the "leans" (vertigo), the same as would be expected in the aircraft. One pilot responded that he experienced some eye strain. This may have been due to squinting trying to see objects more clearly.

SECTION 4 - CONCLUSIONS

Page and paragraph references shown below contain supporting data relating to each conclusion.

4.1 The VIDS display was evaluated as capable of supporting USAF Formal Training unit (FTU) and USN/USMC Fleet Replacement Squadron (FRS) training for 33% (4 of 12) of the single aircraft tasks and 40% (8 of 20) of the multiple aircraft tasks evaluated based upon the composite ratings. (para 3.1.1.2 and Figures 3-2 and 3-3)

4.2 The VIDS provides a display of both background imagery and target and other aircraft imagery as well as a fixed HUD HRI without the use of any additional devices such as head and eye trackers. Although background resolution is less than that required for low level navigation, ground target identification and other low altitude tasks, target aircraft resolution is acceptable. (para 3.2.1)

4.3 Visual threat simulations must be significantly improved to provide acceptable training. (para 3.1.1.2.2.1.3 and paras 3.1.1.2.3.3, 3.1.1.2.3.3.1 and 3.1.1.2.3.3.2)

4.4 Significant improvements in display resolution, database content, and texturing are required to improve the low altitude and visual weapons delivery training capability of the system. (para 3.1.1.2.2.1, para 3.1.1.2.2.3, para 3.1.1.2.3.2.2)

4.5 Both the image detail provided by the IG/database and the resolution provided by the background projectors limit the acuity of the VIDS background imagery. This in turn limits the utility of the system to support specific training tasks related to air-to-surface. The projector resolution limits were demonstrated by the use of the HUD HRI. The HUD HRI showed that by projecting a narrower FOV, which provided more pixels and higher projected resolution, the image quality increased significantly making several tasks more trainable. This result was obtained even though the database was not changed. (para 3.2.1.7)

4.6 A FFOV display is required to adequately train a number of specific tasks including Tactical Formation, Defensive Ranging, Defensive BFM, High Aspect BFM, and ACM. (para 3.1.2.1)

4.7 The VIDS poses some reliability and maintainability issues. The system might require more maintenance by more highly skilled maintenance personnel due to the number of projectors which must maintain alignment to provide seamless background imagery as well as smooth target image movement across multiple screen joints. (para 3.2.2)

4.8 While the display system exhibited some significant resolution limitations, the overall training potential of the system was severely restricted by the image generator and database used in this evaluation, especially for single aircraft tasks. (para 3.1.1.2)

4.9 The apparent higher resolution of the display background imagery projected by the HUD projector indicated that the resolution limitations of the background scene originate, at least partially, from the background projectors rather than the database and IG. This does not indicate

that the database is adequate, but only that projector background resolution is limiting system acuity. (para 3.2.1.7)

4.10 There were no significant instances of simulator sickness such as nausea or disorientation reported during the evaluation. (para 3.2.6.4)

SECTION 5 - RECOMMENDATIONS

5.1 Prior to any commitment to procure this or a similar type of display device, a detailed analysis of reliability and maintainability should be conducted to include some demonstrations as required.

5.2 The evaluation process used in the Joint Vis-Eval should be continued to test visual system capabilities against USAF FTU and USN/USMC FRS training tasks. This process will enable the user and the acquisition community to develop more realistic expectations of training systems capability.

5.3 Manufacturers of visual systems need to thoroughly understand the users training requirements to optimize the training capability of the system.

5.4 The training system must be viewed as a matched set of visual and other simulator subsystems designed to meet realistic training requirements. Training capability of the system may be severely limited by any weak subsystem.

5.5 Future evaluations should be preceded by distribution of the planned mission task outline to both the facility operator and visual system manufacturer. Following review of this document, discussions should be held between the evaluation team and these organizations to insure that the operator and manufacturer understand how the evaluation will be conducted and to allow them time to optimize the system to reflect the best potential operation for the evaluation.

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ANNEX A

STATEMENT OF JOINT VISUAL EVALUATION OBJECTIVE

- Determine trainability of Air-to-Air and Air-to-Surface tasks on available visual display technology

  - Trainability is defined as the visual system's ability to present a simulated visual environment which allows development of skills transferable to the aircraft and minimizes development of simulator unique skills

  - Level of training of USAF Formal Training Units (FTU) and USN/USMC Fleet Replacement Squadrons (FRS)

- Demonstrate current visual simulation technology to users

- Get feedback from those users to help define future visual system requirements

- Provide information and data to support future decisions

ANNEX B

EVALUATION TASK OUTLINE

A familiarization mission and two generic tactical evaluation missions were developed to permit each pilot to evaluate each of 19 single aircraft and 54 multi-aircraft tasks and sub tasks. Not all tasks and subtasks were flown on each mission, but the missions were structured to cover each task and subtask at least once during the evaluation. The Familiarization Mission was structured to orient pilots to the F-15C and the visual system as well as overcome "first impressions". Each evaluation mission consisted of a set of suggested events (Air-to-Surface, Air-to-Air, formation, threat reaction, etc.) to evaluate the tasks and subtasks in a mission context. Mission events increased in complexity from single aircraft tasks and subtasks in the beginning of Mission 1 to complex multi aircraft tasks and subtasks later in Mission 1 and in Mission 2. The tasks, subtasks, missions, and mission events were developed by the Joint Vis-Eval Pilot Team during an initial meeting six weeks prior to the evaluation and approved by the Evaluation Team Chief. For the purposes of this evaluation, the underlined exercises were evaluated as tasks; the remainder were considered subtasks.

1. SINGLE AIRCRAFT TASKS

1.1 Low Level (300 - 5k foot AGL)
1.1.1 Navigation
1.1.2 Low Altitude Training (LAT)
1.1.3 Detect/Identify Ground Threat

1.2 Medium Altitude Maneuvering (10k - 20k foot altitude)

1.3 Visual Weapons Delivery
- 1.3.1 Low Altitude
  - 1.3.1.1 Low Angle Strafe (LAS)
  - 1.3.1.2 Low Angle Low Drag (LALD)
  - 1.3.1.3 Low Angle Bomb (LAB)
  - 1.3.1.4 Visual Lay Down (VLD)
- 1.3.2 High Altitude
  - 1.3.2.1 High Angle Strafe (HAS)
  - 1.3.2.2 High Angle Dive Bomb (HD)
  - 1.3.2.3 Dive Bomb (DB)

1.4 Approach/Landing
- 1.4.1 Day
- 1.4.2 Night

1.5 General Situation Awareness (SA)

2. MULTIPLE AIRCRAFT TASKS

- 2.1 Basic Tasks
  - 2.1.1 Close Formation/Formation Rejoin
  - 2.1.2 Weapon System Checks
  - 2.1.3 Ranging Exercises
    - 2.1.3.1 Offensive
    - 2.1.3.2 Defensive
  - 2.1.4 Air-to-Air Exercises
    - 2.1.4.1 Snap Shot
    - 2.1.4.2 Heat to Guns
- 2.2 Tactical Formation
  - 2.2.1 Medium Altitude (10k - 20k foot altitude)
    - 2.2.1.1 Line Abreast/Combat Spread (3k - 12k foot range)
      - Range specified by Flight Lead
    - 2.2.1.2 Wedge/Tactical Wing (3k - 12k foot range)
      - Range specified by Flight Lead
    - 2.2.1.3 Deploy/Rejoin
  - 2.2.2 Low Altitude (300 - 5k foot AGL)
    - 2.2.2.1 Line Abreast/Combat Spread (3k - 12k foot range)
      - Range specified by Flight Lead
    - 2.2.2.2 Wedge/Tactical Wing (3k - 12k foot range)
      - Range specified by Flight Lead
    - 2.2.2.3 Deploy/Rejoin

- 2.3 Threat Reaction
  - 2.3.1 Air-to-Air
  - 2.3.2 Surface-to-Air

- 2.4 Visual Weapons Delivery
  - 2.4.1 Target Identification (IP/Target/Reattack)
  - 2.4.2 Types
    - 2.4.2.1 Low Altitude
      - 2.4.2.1.1 Echelon Attack
        - 2.4.2.1.1.1 Low Angle Strafe (LAS)
        - 2.4.2.1.1.2 Low Angle Low Drag (LALD)
        - 2.4.2.1.1.3 Low Angle Bomb (LAB)
        - 2.4.2.1.1.4 Visual Lay Down (VLD)
      - 2.4.2.1.2 Split Attack
        - 2.4.2.1.2.1 Low Angle Strafe (LAS)
        - 2.4.2.1.2.2 Low Angle Low Drag (LALD)
        - 2.4.2.1.2.3 Low Angle Bomb (LAB)
        - 2.4.2.1.2.4 Visual Lay Down (VLD)

2.4.2.2 High Altitude

2.4.2.2.1 Echelon Attack

2.4.2.2.1.1 High Angle Strafe (HAS)

2.4.2.2.1.2 High Angle Dive Bomb (HD)

2.4.2.2.1.3 Dive Bomb (DB)

2.4.2.2.2 Split Attack

2.4.2.2.2.1 High Angle Strafe (HAS)

2.4.2.2.2.2 High Angle Dive Bomb (HD)

2.4.2.2.2.3 Dive Bomb (DB)

2.5 Air-to-Air Tasks

2.5.1 Intercepts

2.5.1.1 Medium Altitude (10k - 20k foot altitude)

2.5.1.2 Low Altitude (300 - 5k foot AGL)

2.5.1.3 Tally Ho/Visual Identification

2.5.2 Basic Fighter Maneuvering (BFM)

2.5.2.1 9k, 6k, 3k foot range and High Aspect Angle

2.5.2.2 Maneuvering

2.5.2.3 Weapons Employment

2.5.3 Air Combat Maneuvering (ACM)

2.5.3.1 3 - 3.5 Nautical Mile Setups

2.5.3.2 Weapons Employment

2.6 General Situation Awareness (SA)

ANNEX C

JOINT VISUAL EVALUATION SORTIE EVENTS

0. Familiarization Sortie

- 0.1 Takeoff (Single Aircraft)
- 0.2 Low Altitude Training (LAT)
  - 0.2.1 Navigation
  - 0.2.2 Low Altitude Maneuvering
  - 0.2.3 Terrain Masking
- 0.3 Air-to-Surface Weapons Delivery Familiarization
  - 0.3.1 Air-to-Surface Switchology
  - 0.3.2 Low Angle - 10 Degree Pop Up
  - 0.3.3 Low Angle Strafe
  - 0.3.4 Visual Lay Down
  - 0.3.5 Medium Angle - 20 Degree Pop Up
  - 0.3.6 High Angle - 30 Degree Pop Up
- 0.4 Medium Altitude Maneuvering
  - 0.4.1 Aircraft Handling Characteristics (AHC)
  - 0.4.2 Air-to-Air Switchology
- 0.5 Intercepts
  - 0.5.1 Medium Altitude
  - 0.5.2 Low Altitude
- 0.6 Exercises
  - 0.6.1 Offensive/Defensive Ranging Exercises
  - 0.6.2 Heat to Gun Conversions
- 0.7 Offensive BFM (3 Engagements)
  - 0.7.1 9k foot Perch
  - 0.7.2 6k foot Perch
  - 0.7.3 3k foot Perch
- 0.8 Straight in approach for touch and go landing (at IFR minimums)
- 0.9 Overhead traffic pattern to landing (at VFR overhead minimums)

1. Mission 1

- 1.1 Takeoff/Rejoin
- 1.2 Low Altitude Tactical Formation
  - 1.2.1 Low Altitude Training (LAT)
  - 1.2.2 Navigation
  - 1.2.3 Terrain Masking
  - 1.2.4 Threat Reaction
    - 1.2.4.1 Air-to-Air
    - 1.2.4.2 Surface-to-Air

1.3 Initial Point (IP) to Target Run
1.4 Air-to-Surface Attacks / Reattacks
    1.4.1 Low Angle - 10 Degree Pop Up
    1.4.2 Low Angle Strafe
    1.4.3 Visual Lay Down
    1.4.4 Medium Angle - 20 Degree Pop Up
    1.4.5 High Angle - 30 Degree Pop Up

1.5 Medium Altitude Tactical Formation(10k - 20k foot altitude)
    1.5.1 Line Abreast/Combat Spread (3k - 12k foot range)
        - Range specified by Flight Lead
    1.5.2 Wedge/Tactical Wing (3k - 12k foot range)
        - Range specified by Flight Lead
    1.5.3 Deploy/Rejoin
1.6 Intercepts (1 v 1)
    1.6.1 Medium Altitude - High to Low
    1.6.2 Low Altitude - Low to High
    1.6.3 Low Altitude - Level
1.7 Basic Fighter Maneuvering (BFM)
    1.7.1 9k foot Perch
    1.7.2 6k foot Perch
    1.7.3 3k foot Perch
    1.7.4 High Aspect Butterfly
1.8 Exercises
    1.8.1 Offensive/Defensive Ranging Exercises
    1.8.2 Heat to Gun Conversions
1.9 Snap Shot Exercise on RTB
1.10 Straight in approach for touch and go landing (at IFR minimums)
    1.10.1 Day
    1.10.2 Night
1.11 Overhead traffic pattern to landing (at VFR overhead minimums)
    1.11.1 Day Only

2. Mission 2

2.1 Takeoff/Rejoin
2.2 Low Altitude Tactical Formation
    2.2.1 Low Altitude Training (LAT)
    2.2.2 Navigation
    2.2.3 Terrain Masking
    2.2.4 Threat Reaction
        2.2.4.1 Air-to-Air
        2.2.4.2 Surface-to-Air
2.3 Initial Point to Target Run

2.4 Attacks / Reattack
    2.4.1 Low Altitude Split / Echelon Pop Up
    2.4.2 Medium Altitude Fly up / Level Roll-in
2.5 Intercepts to ACM Engagement
    2.5.1 Low Altitude vs Medium Altitude Bandit
        - Stern conversion to ACM
    2.5.2 Medium Altitude vs Medium Altitude Bandit
        - Stern conversion to ACM
    2.5.3 Medium Altitude vs Low Altitude Bandit
        - Beam Conversion to ACM
    2.5.4 Medium Altitude vs Medium Altitude Bandit
        - Radar missile defense
2.6 Straight in approach for touch and go landing (at IFR minimums)
    2.6.1 Day
    2.6.2 Night
2.7 Overhead traffic pattern to landing (at VFR overhead minimums)
    2.7.1 Day Only

ANNEX D

BACKGROUND OF EVALUATION PILOTS

Eight pilots were selected for this evaluation including four Air Force, two Navy, and two Marine pilots. All pilots had extensive fighter and fighter instructor pilot experience in the F-15, F-16, or FA-18 with one of the pilots having combat experience. Both Marine pilots were Top Gun graduates. The average flying time for the pilots was 2275 hours; average instructor time was 788 hours. Each pilot completed the following background questionnaire at the start of Joint Vis-Eval Site 1. The same eight pilots performed the Site 2 evaluation at McDonnell Douglas.

PILOT BACKGROUND QUESTIONNAIRE

NAME AND GRADE_____
DATE_____

ORGANIZATION
_____LOCATION_____

PILOT NUMBER_____TELEPHONE:
COMMERCIAL_____
DSN_____

FAX_____

TYPE OF AIRCRAFT PRESENTLY FLYING : (Check one and indicate hours flown)

F-15C___ F-15E___ F-16C___Block#___ FA-18___ F-14___

Hours_____
IP Hours_____

COMBAT EXPERIENCE:

Aircraft Type:_____ Combat Hours_____ Combat Missions_____

CURRENT DUTY: (e.g., instructor pilot, staff officer, etc.)
_____

OTHER INSTRUCTOR AND FIGHTER AIRCRAFT FLYING EXPERIENCE:
(list aircraft and approximate flying hours)

_____
_____
_____
_____
_____
_____

TOTAL FLYING TIME_____ **TOTAL IP TIME**_____

ANNEX E
JOINT VISUAL EVALUATION RATING SCALE

0.....Provides negative training. Training detracts from performance in aircraft or encourages hazardous techniques. Has major deficiencies.

1.....No similarity between visual simulation and aircraft training. Cannot train requirement with visual system. Has major deficiencies.

2.....Little similarity between visual simulator and aircraft training. Only minimal training can be accomplished using visual system.

3.....Training capability is acceptable. Essential parts of the task can be taught with this visual system.

4.....Visual training capability is nearly equal to that experienced in the aircraft. Most of the task can be trained with this visual system.

5.....Training capability equal to that experienced in the aircraft. Task can be fully trained with visual system.

Comment Considerations

Comment on any of the following conditions if they contributed to a rating of less than 3 for any task or sub-task.

A. Did you have to perform any task differently in the simulator than you would in the aircraft?

B. Were there any required cues that were different or missing in the simulator?

C. Were you able to determine range, rate of closure and aspect angle with sufficient accuracy to perform the task?

D. Did the aircraft, aircraft system and avionics simulation support performance of the task?

E. Were there any visual display characteristics (i.e. resolution (object detail), brightness, contrast, distortion, field of view, field of regard, area of interest, spurious images, blemishes, transport delay, placement of hardware or other characteristics) that impacted your performance of the task?

F. Were there any data base characteristics that detracted from or enhanced your ability to perform the task?

G. Were the HUD and aircraft systems accurately correlated with the visual system?

H. Were you able to appropriately use in-cockpit references if they were required?

I. What visual system improvements would you consider most important to improve your task ratings?

J. Other?

ANNEX F

SAMPLE DATA COLLECTION FORMS

JOINT VISUAL EVALUATION AIRCREW QUESTIONNAIRE

Name _____
Mission FAM____ 1____ 2____
Date _____
Debriefer _____

TASK RATING SCALE:

0 Provides Negative Training
1 No similarity, cannot train
2 Little similarity, minimal training
3 Acceptable training capability, teach essential parts of task
4 Nearly equal to aircraft, train most of task
5 Nearly equal to aircraft, fully train task

Note: If you rate any task or sub-task less than 3, please circle the condition that applies and explain in comments. If more space is required, use back of page. If a task or sub-task is not performed, enter N/A in rating block.

Section 1 - Single Aircraft Tasks

1.1 Low Level Task Rating ___

1.1.1 Navigation Sub-task Rating ___
1.1.2 Low Altitude Training (LAT) Sub-task Rating ___
1.1.3 Detect / Identify Ground Threat Sub-task Rating ___

If any of the following conditions contributed to a rating of less than 3 for any task or sub-task, circle the condition(s) that apply and explain.

A. Task different in simulator than in aircraft?
B. Required cues different or missing?
C. Range, closure rate, aspect angle accuracy ?
D. Aircraft simulation support the task?
E. Display characteristics impact task?
F. Data base detract from or enhance task?
G. HUD, aircraft, visual accurately correlated?
H. Appropriately use in-cockpit references?
I. Priority improvements to improve ratings?
J. Other

COMMENTS:_____

1.2 Medium Altitude Maneuvering

Task Rating ___

If any of the following conditions contributed to a rating of less than 3 for any task or sub-task, Circle the condition(s) that apply and explain.

A. Task different in simulator than in aircraft?
B. Required cues different or missing?
C. Range, closure rate, aspect angle accuracy ?
D. Aircraft simulation support the task?
E. Display characteristics impact task?
F. Data base detract from or enhance task?
G. HUD, aircraft, visual accurately correlated?
H. Appropriately use in-cockpit references?
I. Priority improvements to improve ratings?
J. Other

COMMENTS:_____

1.3 Visual Weapons Delivery

Task Rating ___

1.3.1 Low Altitude — Sub-task Rating___
- 1.3.1.1 Low Angle Strafe (LAS) — Sub-task Rating ___
- 1.3.1.2 Low Angle Low Drag (LALD) — Sub-task Rating ___
- 1.3.1.3 Low Angle Bomb (LAB) — Sub-task Rating ___
- 1.3.1.4 Visual Lay Down (VLD) — Sub-task Rating ___

1.3.2 High Altitude — Sub-task Rating___
- 1.3.2.1 High Angle Strafe (HAS) — Sub-task Rating ___
- 1.3.2.2 High Angle Dive Bomb (HD) — Sub-task Rating ___
- 1.3.2.3 Dive Bomb (DB) — Sub-task Rating ___

If any of the following conditions contributed to a rating of less than 3 for any task or sub-task, circle the condition(s) that apply and explain.

A. Task different in simulator than in aircraft?
B. Required cues different or missing?
C. Range, closure rate, aspect angle accuracy ?
D. Aircraft simulation support the task?
E. Display characteristics impact task?
F. Data base detract from or enhance task?
G. HUD, aircraft, visual accurately correlated?
H. Appropriately use in-cockpit references?
I. Priority improvements to improve Ratings?
J. Other

COMMENTS:_____

1.4 Approach/Landing

Task Rating ___

1.4.1 Day — Sub-task Rating ___

1.4.2 Night — Sub-task Rating ___

If any of the following conditions contributed to a rating of less than 3 for any task or sub-task, circle the condition(s) that apply and explain.

A. Task different in simulator than in aircraft?
B. Required cues different or missing?
C. Range, closure rate, aspect angle accuracy ?
D. Aircraft simulation support the task?
E. Display characteristics impact task?
F. Data base detract from or enhance task?
G. HUD, aircraft, visual accurately correlated?
H. Appropriately use in-cockpit references?
I. Priority improvements to improve ratings?
J. Other

COMMENTS:_____

1.5 General Situation Awareness (SA)

Task Rating ___

If any of the following conditions contributed to a rating of less than 3 for any task or sub-task, circle the condition(s) that apply and explain.

A. Task different in simulator than in aircraft?
B. Required cues different or missing?
C. Range, closure rate, aspect angle accuracy ?
D. Aircraft simulation support the task?
E. Display characteristics impact task?
F. Data base detract from or enhance task?
G. HUD, aircraft, visual accurately correlated?
H. Appropriately use in-cockpit references?
I. Priority improvements to improve ratings?
J. Other

COMMENTS:_____

Section 2 - Multiple Aircraft Tasks

2.1 Basic Tasks	Task Rating___
2.1.1 Close Formation/Formation Rejoin	Sub-task Rating___
2.1.2 Weapon System Checks	Sub-task Rating___
2.1.3 Ranging Exercises	Sub-task Rating___
2.1.3.1 Offensive	Sub-task Rating___
2.1.3.2 Defensive	Sub-task Rating___
2.1.4 Air-to-Air Exercises	Sub-task Rating___
2.1.4.1 Snap Shot	Sub-task Rating___
2.1.4.2 Heat to Guns	Sub-task Rating___

If any of the following conditions contributed to a rating of less than 3 for any task or sub-task, circle the condition(s) that apply and explain.

A. Task different in simulator than in aircraft?
B. Required cues different or missing?
C. Range, closure rate, aspect angle accuracy ?
D. Aircraft simulation support the task?
E. Display characteristics impact task?
F. Data base detract from or enhance task?
G. HUD, aircraft, visual accurately correlated?
H. Appropriately use in-cockpit references?
I. Priority improvements to improve ratings?
J. Other

COMMENTS:_____

_____

_____

_____

_____

_____

_____

_____

2.2 Tactical Formation	Task Rating___
2.2.1 Medium Altitude (10k-20k foot altitude)	Sub-task Rating___
2.2.1.1 Line Abreast/Combat Spread (3k-12k foot range)	Sub-task Rating___
2.2.1.2 Wedge/Tactical Wing (3k-12k foot range)	Sub-task Rating___
2.2.1.3 Deploy/Rejoin	Sub-task Rating___
2.2.2 Low Altitude (300 - 5k foot AGL)	Sub-task Rating___
2.2.2.1 Line Abreast/Combat Spread (3k-12k foot range)	Sub-task Rating___
2.2.2.2 Wedge/Tactical Wing (3k-12k foot range)	Sub-task Rating___
2.2.2.3 Deploy/Rejoin	Sub-task Rating___

If any of the following conditions contributed to a rating of less than 3 for any task or sub-task, circle the condition(s) that apply and explain.

A. Task different in simulator than in aircraft?
B. Required cues different or missing?
C. Range, closure rate, aspect angle accuracy ?
D. Aircraft simulation support the task?
E. Display characteristics impact task?
F. Data base detract from or enhance task?
G. HUD, aircraft, visual accurately correlated?
H. Appropriately use in-cockpit references?
I. Priority improvements to improve ratings?
J. Other

COMMENTS:_____

_____

2.3 Threat Reaction — Task Rating___

2.3.1 Air-to-Air — Sub-task Rating___

2.3.2 Surface-to-Air — Sub-task Rating___

If any of the following conditions contributed to a rating of less than 3 for any task or sub-task, circle the condition(s) that apply and explain.

A. Task different in simulator than in aircraft?
B. Required cues different or missing?
C. Range, closure rate, aspect angle accuracy ?
D. Aircraft simulation support the task?
E. Display characteristics impact task?
F. Data base detract from or enhance task?
G. HUD, aircraft, visual accurately correlated?
H. Appropriately use in-cockpit references?
I. Priority improvements to improve ratings?
J. Other

COMMENTS:_____

2.4 Visual Weapon Delivery — Task Rating___

2.4.1 Target Identification (IP/Target/Reattack) — Sub-task Rating___

2.4.2 Types

2.4.2.1 Low Altitude — Sub-task Rating___

2.4.2.1.1 Echelon Attack — Sub-task Rating___

2.4.2.1.1.1 Low Angle Strafe (LAS) — Sub-task Rating___

2.4.2.1.1.2 Low Angle Low Drag (LALD) — Sub-task Rating___

2.4.2.1.1.3 Low Angle Bomb (LAB) — Sub-task Rating___

2.4.2.1.1.4 Visual Lay Down (VLD) — Sub-task Rating___

2.4.2.1.2 Split Attack — Sub-task Rating___

2.4.2.1.2.1 Low Angle Strafe (LAS) — Sub-task Rating___

2.4.2.1.2.2 Low Angle Low Drag (LALD) — Sub-task Rating___

2.4.2.1.2.3 Low Angle Bomb (LAB) — Sub-task Rating___

2.4.2.1.2.4 Visual Lay Down (VLD) — Sub-task Rating___

2.4.2.2 High Altitude — Sub-task Rating___

2.4.2.2.1 Echelon Attack — Sub-task Rating___

2.4.2.2.1.1 High Angle Strafe (HAS) Sub-task Rating___

2.4.2.2.1.2 High Angle Dive Bomb (HD) — Sub-task Rating___

2.4.2.2.1.3 Dive Bomb (DB) Sub-task Rating___
2.4.2.2.2 Split Attack Sub-task Rating___
2.4.2.2.2.1 High Angle Strafe (HAS) Sub-task Rating___
2.4.2.2.2.2 High Angle Dive Bomb (HD) Sub-task Rating___
2.4.2.2.2.3 Dive Bomb (DB) Sub-task Rating___

If any of the following conditions contributed to a rating of less than 3 for any task or sub-task, circle the condition(s) that apply and explain.

A. Task different in simulator than in aircraft?
B. Required cues different or missing?
C. Range, closure rate, aspect angle accuracy ?
D. Aircraft simulation support the task?
E. Display characteristics impact task?
F. Data base detract from or enhance task?
G. HUD, aircraft, visual accurately correlated?
H. Appropriately use in-cockpit references?
I. Priority improvements to improve ratings?
J. Other

COMMENTS:_____

2.5 Air-to-Air Tasks Task Rating___

2.5.1 Intercepts Sub-task Rating___
2.5.1.1 Medium Altitude (10k - 20k foot altitude) Sub-task Rating___
2.5.1.2 Low Altitude (300 - 5k foot AGL) Sub-task Rating___
2.5.1.3 Tally Ho/Visual Identification Sub-task Rating___
2.5.2 Basic Fighter Maneuvering (BFM) Sub-task Rating___
2.5.2.1 3k, 6k, 9k foot range and High Aspect Angle Sub-task Rating___
2.5.2.2 Maneuvering Sub-task Rating___
2.5.2.3 Weapons Employment Sub-task Rating___
2.5.3 Air Combat Maneuvering Sub-task Rating___
2.5.3.1 3 - 3.5 Nautical Mile Setups Sub-task Rating___
2.5.3.2 Weapons Employment Sub-task Rating___

If any of the following conditions contributed to a rating of less than 3 for any task or sub-task, circle the condition(s) that apply and explain.

A. Task different in simulator than in aircraft?
B. Required cues different or missing?
C. Range, closure rate, aspect angle accuracy ?
D. Aircraft simulation support the task?
E. Display characteristics impact task?
F. Data base detract from or enhance task?
G. HUD, aircraft, visual accurately correlated?
H. Appropriately use in-cockpit references?
I. Priority improvements to improve ratings?
J. Other

COMMENTS:_____

2.6 General Situation Awareness (SA) Task Rating___

COMMENTS:_____

Section 3 - General Questions

3.1 What major strengths did you observe in this visual display during this evaluation?

3.2 What major weaknesses did you observe in this visual display during this evaluation?

3.3. During this evaluation sortie, did you experience any physical discomfort such as:

- Simulator sickness (nausea or vomiting)?
- Disorientation?
- Eyestrain?

If so, please describe.

ANNEX G

Composite Ratings

	SINGLE AIRCRAFT	Rating
	Percentage of Pilots Rating 3 or Higher	Composite
1.2	**Medium Altitude Maneuvering(T)**	100
	Visual Weapons Delivery	
1.3.1	Low Altitude (T)	86
1.3.1.1	Low Angle Strafe	86
1.3.1.2	Low Angle Low Drag	86
1.3.1.3	Low Angle Bomb	100
1.3.1.4	Visual Lay Down	83
1.4	**Approach/Landing (T)**	80
1.4.1	Day (T)	100

(T) Differentiates Tasks From Subtasks

Table 3-1 Single Aircraft Tasks and Subtasks Meeting Acceptable Training Criteria

	MULTIPLE AIRCRAFT	Rating
	Percentage of Pilots Rating 3 or Higher	Composite
2.1	**Basic Tasks (T)**	86
2.1.2	Weapon System Checks **(T)**	100
2.1.3	Ranging Exercises **(T)** **	86
2.1.3.1	Offensive	86
2.1.4	Air-to- Air Exercises **(T)**	86
2.1.4.1	Snap Shot	86
2.1.4.2	Heat to Guns	86
2.2	**Tactical Formation (T)** **	87
2.2.1	Medium Altitude (10-20K Feet) **(T)** **	100
2.2.1.1	Line Abreast/Cbt Sprd (3-12K Ft Rng)	87
2.2.1.2	Wedge/Tact Wg (3-12K Foot Range)	100
2.2.1.3	Deploy/Rejoin	93
2.2.2	Low Altitude (300-5K Feet AGL) **(T)** **	80
2.2.2.1	Line Abreast/Cbt Sprd (3-12K Ft Rng)	80
2.2.2.2	Wedge/Tact Wg (3-12K Foot Range)	80
2.2.2.3	Deploy/Rejoin	80
2.4	**Visual Weapons Delivery (T)**	83
2.4.2	Types	
2.4.2.1	Low Altitude **(T)**	92
2.4.2.1.1	Echelon Attack	90
2.4.2.1.1.1	Low Angle Strafe	90
2.4.2.1.1.2	Low Angle Low Drag	82
2.4.2.1.1.3	Low Angle Bomb	91
2.4.2.1.1.4	Visual Lay Down	100
2.4.2.1.2	Split Attack	82
2.4.2.1.2.1	Low Angle Strafe	83
2.4.2.1.2.3	Low Angle Bomb	82
2.4.2.1.2.4	Visual Lay Down	83
2.5	**Air-to-Air Tasks (T)**	94
2.5.1	Intercepts **(T)**	94
2.5.1.1	Medium Altitude (10-20K Feet)	94
2.5.1.2	Low Altitude (300-5K Feet AGL)	81
2.5.2	Basic Fighter Maneuvering **(T)** **	86
2.5.2.2	Maneuvering	86
2.5.2.3	Weapons Employment	93
	Air Combat Maneuvering	
2.5.3.2	Weapons Employment	86
2.6	**General Situation Awareness (T)**	80

**** Tasks Not Meeting Second Criterion (Downgraded To Not Acceptable)**

(T) Differentiates Tasks From Subtasks

Table 3-2 Multiple Aircraft Tasks and Subtasks Meeting Acceptable Training Criteria

	SINGLE AIRCRAFT	Rating
	% of Pilots Rating 3 or Higher	Composite
1.1	**Low Level (T)**	64
1.1.1	Navigation (T)	50
1.1.2	Low Altitude Training (T)	71
1.1.3	Detect/ID Ground Threat (T)	50
1.3	**Visual Weapons Delivery (T)**	79
1.3.2	High Altitude (T)	64
1.3.2.1	High Angle Strafe	54
1.3.2.2	High Angle Dive Bomb	64
1.3.2.3	Dive Bomb	64
	Approach/Landing	
1.4.2	Night (T)	33
1.5	**General Situation Awareness (T)**	63
	MULTIPLE AIRCRAFT	Rating
	% of Pilots Rating 3 or Higher	Composite
	Basic Tasks	
2.1.1	Close Formation/Form Rejoin (T)	57
	Ranging Exercises	
2.1.3.2	Defensive	50
2.3	**Threat Reaction (T)**	56
2.3.1	Air-to-Air (T)	56
2.3.2	Surface-to-Air (T)	58
	Visual Weapons Delivery	
2.4.1	Target ID (IP/Target/Reattack) (T)	42
	Low Altitude	
	Split Attack	
2.4.2.1.2.2	Low Angle Low Drag	73
2.4.2.2	High Altitude (T)	67
2.4.2.2.1	Echelon Attack	67
2.4.2.2.1.1	High Angle Strafe	67
2.4.2.2.1.2	High Angle Dive Bomb	67
2.4.2.2.1.3	Dive Bomb	67
2.4.2.2.2	Split Attack	50
2.4.2.2.2.1	High Angle Strafe	56
2.4.2.2.2.2	High Angle Dive Bomb	50
2.4.2.2.2.3	Dive Bomb	50
	Air-to-Air Tasks	
	Intercepts	
2.5.1.3	Tally Ho/Visual ID	69
	Basic Fighter Maneuvering	
2.5.2.1	3K,6K,9K Ft Rng & Hi Aspect Angle	71
2.5.3	Air Combat Maneuvering (T)	71
2.5.3.1	3-3.5 Nautical Mile Setups	79

(T) Differentiates Tasks From Subtasks

Table 3-3 Single and Multiple Aircraft Tasks and Subtasks Not Meeting Acceptable Training Criteria

ANNEX H

DETAILED HARDWARE DESCRIPTION
SITE 2

Detailed Hardware Description. The display performance characteristics shown here were provided by McDonnell Douglas (Display) and Evans and Sutherland (IG and Data Base). No measurements were attempted during evaluation.

GENERAL	
Display Name	Visual Integrated Display System (VIDS).
Display Type	Four channel rear projection display with target projectors.
Location	McDonnell Douglas Corp., St. Louis, MO.
Manufacturer	McDonnell Douglas Corp., St. Louis, MO.
Image Generator	Evans and Sutherland ESIG-HD 3000 AT.

BACKGROUND DISPLAY ATTRIBUTES	
Type Image	Real Image. Four edge matched screens located 28 inches from pilot's eye.
Projectors	As Configured: Five high resolution full color CRT projectors.
Resolution	As Configured: better than 13.0 arc minutes per line pair.
Field of View	216 degrees horizontal by 135 degrees vertical - Expandable to 360 degrees by adding three more channels.
Image Mismatch Across Joints	Not measured - Not readily detectable.
Brightness Variation Across Joints	< 50%.
Geometric Correction	Yes - Static only required.
Spurious Images	None.
HUD/Display Correlation	Less than one pixel.
Viewing volume	Real Image.
Parallax	Yes, because it is a real image.
Colors	256.

TARGET PROJECTORS	
Number Targets	Multiple simultaneous high resolution targets.
Range	Programmable
Mismatch Across Joints	Not measured - Normally not readily detectable.

HUD PROJECTOR	
Type Projector	Monochrome (green) CRT Refractive Optics.
Field of View	22 degrees by 15 degrees.

IMAGE GENERATION	
System Capacity	3300 potentially visible polygons/channel (13,200 polygons/system) including polygons, lights, models for system operation at 60 Hz. Lights are

	traded off 2.5 to 1. 6600 potentially visible polygons/channel (26,400 polygons/system) for system operation at 30 Hz.
Texture	Types: full color, intensity modulated, contour modulated, and photo with 386 maps of 512 by 512 texels.
Calligraphic Lights	None.
Polygons/Raster Lights	6000 polygons with 1500 lights/channel at 30 Hz. Moving models subtract from this capacity.
Moving Models	System is capable of controlling a maximum of 253 moving models. Models are traded with polygons and lights. Practical moving model capacity at any time is approximately 128 models at 30 Hz, 64 models at 60 Hz.
Translucency	24 levels.
Ambient Light	Day/Night/Dusk with continuous time of day.
Surface Shading	Smooth, curved, and fixed.
Sun Angle	Set 65 degree elevation.
Anti Aliasing	Equivalent to 4 X 4 pixels.
Visual Range	100 km for Vis-Eval database.
Haze/Visibility	Yes. Visibility fully adjustable.
Clouds	Two independent decks. Fully adjustable. Scud available for cloud top and bottom, and randomly.
Horizon	Directional Horizon. 32 bit intensity setting.
Thunderstorm/ Lightning	Five levels of storm intensity with lightning flashes and visibility degradation. No rendered storm model.
Special Effects	Explosions, dust clouds, launch flash, and steerable landing light lobes.
Level-of-Detail Ranges	Three or more for models depending upon requirements. Six levels for terrain.
Occultation Levels	Models are range buffered with a depth buffering of 2.5 to 1. 225 million pixels/second/channel processed yields 90 million rendered pixels/second/ channel. Terrain uses separation planes.
Update Rate	60 Hz (except 30 Hz with HUD area AOI insert).
Transport Delay	58 milliseconds (60 Hz update rate), 100 milliseconds (30 Hz).
Positional Accuracy	64 bit positional accuracy with respect to the database modeled location.
Pixel Rendering	1.5 million anti-aliased fully rendered pixels/channel at 60 Hz, 3 million pixels/channel at 30 Hz.
Crash Detection	Yes. For ground, features, and models. Enhanced processing for fast moving objects, such as jet aircraft; however not installed for evaluation.
Distracting Effects	Feature mis-match on DFAD boundaries.
On-Line Data Base	32 Mbytes or approximately a 35 mile circle about ownship position.

Note: All characteristics listed are as-tested. The ESIG-HD/3000 system can be expanded significantly beyond the configuration used for this evaluation. Maximum, single eye-point capability is over twice the capacity of the demonstration system.

DATA BASE	
Geographic Location	Central California, including Hunter Liggett and NAS Lemoore. Center of database at 36 degrees, North latitude, and 119 degrees, West longitude.
Model Level-of-Detail	Three or more depending upon requirements.
Moving Models	Typical of the models available include F-15, SA-6, UH-60, F-16, F-4, MIG-29, MIG-23, MIG-21, TU-95, SU-27, MI-24 Hind, Backfire Bomber, KC-10, BMP-2, M-1975 SPG, Nimitz class carrier, MI tank, T-72 tank, and Freighter.
Model Library	E&S RapidDatabase model library.

Airfields	Generic airfields to represent numerous small airfields along mission routes (placed per DFAD data). Large generic airfield to represent NAS Lemoore.
Light Models	Strobes, directional landing lights, VASI, PAPI, etc.
Data Base Size	311 nautical miles East-West by 124 nautical miles North-South.
Airfield Size	Generic- two sizes - austere airfield runway length 610 meters, larger airfield runway lengths of 2440 and 3050 meters.
Texture Maps	Various sizes, from 64x64 to 512x512 texels, 18 levels.
Polygon Allocation per screen	3300 Polygons total, 1650 terrain and features, 1350 models, 300 reserve.
Source Data	DFAD and DTED Level 1.

Note: This database, an E&S RapidDatabase ™, was produced in two weeks using DMA source materials and enhanced along the mission routes using inputs from USAF personnel. DMA source data problems were generally not corrected unless they were in view of the mission route.